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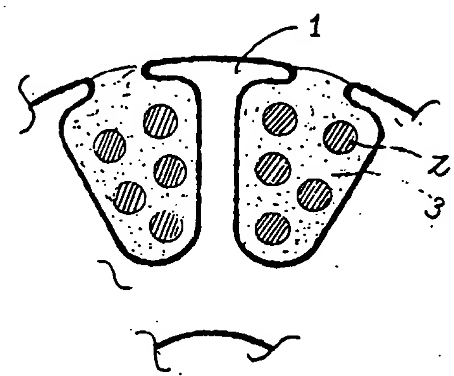
(54) **Coating material for armature coil of a motor for electrical equipment.**

(57) In a motor in which a copper armature coil (2) wound around an iron armature core (1) is fixed to the armature core (1) by coating a resin coating material (3) on the armature coil by impregnation, crack generation in the coating material is prevented. The coefficient of thermal expansion of the coating material is set to a value between the coefficient of thermal expansion of copper and that of iron.

Fig. 2



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Background of the Invention

Field of the Invention:

The present invention relates to a coating material for an armature coil of a motor for !ectrical equipm nt. The motor can be, for example, a starter motor, a wiper motor, a power window motor, a power seat motor or a sunroof motor.

Description of the Related Art

In the above-described type of motors for electrical equipment, a copper armature core, which is wound around a slot formed in an iron armature core, is fixed to the armature core by coating a resin coating material (fillers) on the armature coil by impregnation. Consequently, in such a motor, even when the armature is rotated at a high speed, abrasion of the armature coil or projection of the armature coil from the slot is eliminated, thus eliminating breakage of the coil or peeling-off of an insulating film which impairs the insulation property. Therefore, a reliable motor is provided.

Motors for the electrical equipment may be installed near an engine, such as a starter motor. Such motors are heated to 150 °C or above when the engine heated to a high temperature. The vehicle may be parked in a severe cold region where the temperature may fall to -40 °C or below. Thus, the requirement of the motor is that the motor can withstand such a great temperature difference.

However, it is difficult for the conventional motor to withstand such a great temperature difference. Consequently, the coating material may be cracked, making the motor unreliable. Hence, the present inventors made intensive studies regarding the reasons for crack generation, found that crack generation has a relation with the coefficient of thermal expansion of the coating material, and completed the present invention on the basis of the obtained knowledges.

Summary of the Invention

In view of the aforementioned problems of the prior art, an object of the present invention is to provide a coating material for an armature coil for a motor for electrical equipment which is capable of overcoming th aforementioned problems. In a motor for electrical equipment of the type in which an armature coil made of copper is wound around a slot formed in an armature core made of iron, the coating material coated on the armature coil by impregnation to fix the armature coil to the armature core is made of a resin and has a coefficient of thermal expansion which is between the coefficient of thermal expansion of copper and the coefficient of thermal expansion of iron.

It is therefore possible according to the present invention to effectively eliminate generation of cracks in the coating material due to a great temperature difference.

The invention will be described now by way of example only, with reference to the accompanying drawings. In the drawings:

Fig. 1 is a front view, with part broken away, of an armature core, and

Fig. 2 is a B-B cross section of an armature core.

Description of the Preferred Embodiment

An embodiment of the present invention will be described below with reference to the accompanying drawing. In the figure, reference numeral 1 denotes an armature core which constitutes a motor for the electrical equipment. The armature core 1 is an assembly of a plurality of thin plat-like laminations of a core material made of iron. An armature coil 2 made of copper is wound around a slot 1a formed in the armature core 1. A resin coating material is coated on the armature core 1 with the armature coil 2 wound around by impregnation to fix the armature coil 2 to the armature core 1.

The present inventors conducted experiments in the manner described below to examine the relation between the coefficient of thermal expansion and crack generation. That is, the present inventors carried ut the simulation test in the manner described below. First, th armature cores 1 were manufactured. These armature cores 1 wer coated by impregnation with substantially the same amount of coating materials 3 having diff rent coefficients of thermal expansion shown below under substantially the same conditions. Each of the manufactured armatur cores 1 was rotated at a speed of 2000 revolutions/min (rpm) whil the temperature of the atmosphere thereof was raised from -50 °C to 200 °C in 10 minutes. At 200 °C, the armature core 1 was rotated for another 20 minutes. After the rotation of the armature core 1 was stopp d, the temperature of the

atmosphere was cooled from 200 °C to -50 °C in 30 minutes, and was then maintained to -50 °C for 20 minutes. A seri s of the above-described operations w re repeat d 20 times. Th reaft r, the armature core 1 was removed to observe incidence of crack generation in the coating material 3. The coating materials 3 selected in the above-described simulati n test were diallyl phthalate impregnated with 70% of glass fiber. Four types of coating materials respectively having coefficients of thermal expansion (which are coefficients of linear expansion) of 2.55 x 10^{-5} (comparative example 1), 1.96 x 10^{-5} (comparative example 2), 1.51 x 10^{-5} (example 1) and 1.36 x 10^{-5} (example 2) were prepared. The coefficient of thermal expansion of each of the coating materials was adjusted by crosslinking (bridging) of styrene oligomer. To take variations in the tests into account, three coating material samples were used in each of the tests. Table 1 shows the results of the tests. Crack generation was evaluated by visually observing the sliced two surfaces of a coil end portion A of th armature core 1, the sliced two surfaces of a core portion B thereof, and the two axially cut surfaces of an armature core portion C.

TABLE 1

Sample	No.	Coefficient of Thermal Expansion (x 10^{-5})	Incidence of Crack Generation		
			Portion A	Portion B	Portion C
Example 1	1	1.51	Non	Non	Slightly Generated
	2	1.51	Non	Non	Non
	3	1.51	Slightly Generated	Non	Non
Example 2	1	1.36	Non	Non	Non
	2	1.36	Non	Non	Non
	3	1.36	Non	Non	Non
Comparative Example 1	1	2.55	High Occurence	High Occurence	High Occurence
	2	2.55	High Occurence	Moderate Occurence	High Occurence
	3	2.55	Moderate Occurence	High Occurence	High Occurence
Comparative Example 2	1	1.96	High Occurence	Slight Occurence	Slight Occurence
	2	1.96	Moderate Occurence	Slight Occurence	Moderate Occurence
	3	1.96	Moderate Occurence	Slight Occurence	High Occurence

It is clear from Table 1 that crack generation was observed more or less in Comparative Examples 1 and 2 in which the coating materials 3 had a high coefficient of thermal expansion and that no crack was generated at all or cracks were generated at a low level that does not matter at all in Examples 1 and 2. That is, the coefficient of thermal expansion of iron which is the material of the armature core 1 is about 1.15 x 10^{-5}. The coefficient of linear expansion of copper which is the material of the armature coil 2 ranges from 1.54 x 10^{-5} to 1.62 x 10^{-5}. In Examples 1 and 2 in which substantially no crack was generated, the coefficients of thermal expansion of the coating materials 3 were 1.51 x 10^{-5} and 1.36 x 10^{-5}, which were between the coefficient of thermal expansion of iron and that of copper. It can therefore be inferred from the above-mentioned results that generation of cracks in the coating material 3 due to a temperature difference is greatly affected by the coefficient of thermal xpansion thereof which differs in materials. Thus, ven in the motor which is disposed at a site where there is a great temperature difference, generation of cracks can be effectively avoided by using the coating material 3 having a coefficient of thermal expansion which is between the coefficient of thermal expansion of iron and that of copper, like the above-described exampl s. As a result, the reliability of the mot r

is improved.

Besides a diallyl phthalate resin, an unsaturated polyester resin or an epoxy resin can also b used as the main compon nt of the coating material. Such a resin is crosslinked (bridged) using a crosslinking (bridging) agent, such as styrene oligomer or allyl oligomer, to adjust the coefficient of thermal expansion thereof to a value between the coefficient of thermal expansion of iron and that of copper. The present inventors conducted the same experiments as the above-described ones using such coating materials, and obtained the same results.

As will be understood from the foregoing description, generation of cracks due to a temperature difference can be effectively avoided by using the coating material having a coefficient of thermal expansion which is between the coefficient of thermal expansion of iron and that of copper. Consequently, even when the motor is used at a site where there is a great temperature difference, it can be used reliably.

Claims

1. A coating material for an armature coil of a motor for electrical equipment in which the armature coil is made of copper and wound around a slot formed in an armature core made of iron,
   characterised in that said coating material, which is coated on said armature coil by impregnation to fix said armature coil to said armature core, is made of a resin and has a coefficient of thermal expansion which is between the coefficient of thermal expansion of copper and the coefficient of thermal expansion of iron.

2. A method of forming an armature coil for a motor for use in electrical equipment comprising winding an armature coil made of copper around a slot in an armature core made of iron and coating the armature coil with a coating material to fix the armature coil to said armature core, characterised in that the coating material has a coefficient of thermal expansion which is between that of copper and iron.

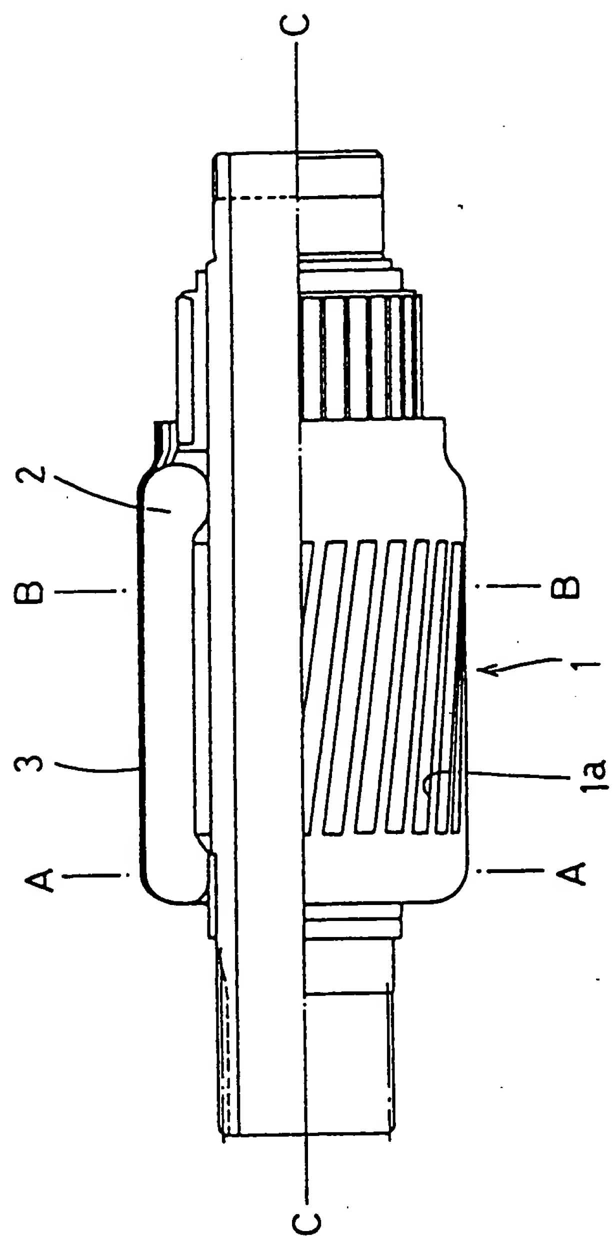
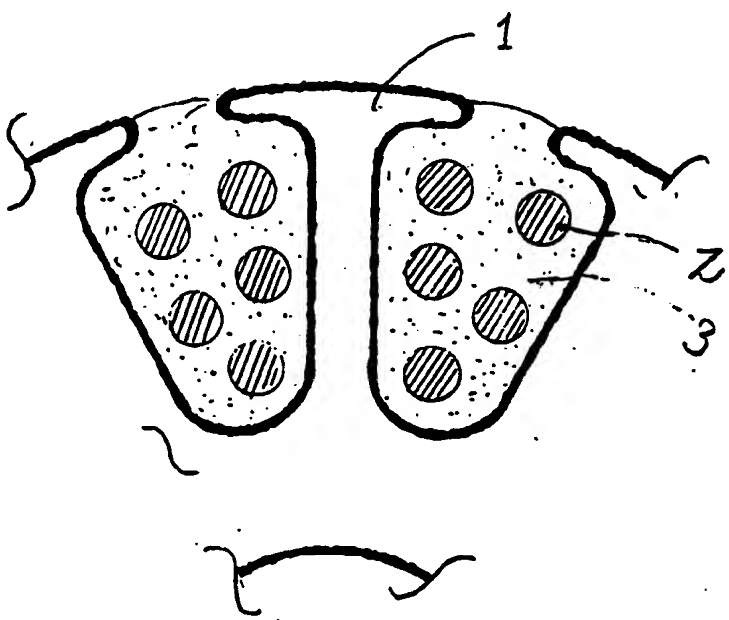

C
2
B
B
1
3
1a
A
A
C

Fig. 2



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EUROPEAN SEARCH REPORT

Application Number

EP 93 30 3778

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-2 846 599 (MCADAM) * column 1, line 57 - column 4, line 33; figures 1-6 * -----	1,2	H02K3/32 H02K15/12
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 AUGUST 1993	TIO K.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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